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United States
Department of
Agriculture

Forest Service

Alaska Region
Report
Number 71

Bird Population Responses to Clearcutting

in the Tongass National Forest of Southeast Alaska

Bird Population Responses to Clearcutting in the Tongass National Forest of Southeast Alaska, by Winifred B. Kessler. U. S. Department of Agriculture, Forest Service, Alaska Region, Tongass National Forest, Ketchikan Area (Federal Building, Ketchikan, Alaska 99901). Alaska Region report number 71, September 1979.

Preface

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Bird Population Responses to Clearcutting

in the Tongass National Forest of Southeast Alaska.

Introduction

Timber management is a major land management activity in the Tongass National Forest of southeast Alaska. This forest, with an area of approximately 6.2 million hectares, is the nation's largest national forest. About a third of Tongass land supports timber stands of commercial value (Harris and Farr 1974). Between 1951 and 1956, the Tongass National Forest awarded three long-term timber sales for a total contract timber volume of about 13,918 million board feet measure (MM bm) (USDA Forest Service 1978). The present rate of harvest on these sales is about 300 MM bm annually. The Tongass National Forest has an additional commitment to harvest at least 80 MM bm annually in sales to smaller business enterprises. Timber management on a scale of this magnitude has a profound effect on all resources of the Tongass National Forest.

The Forest and Rangeland Renewable Resources Planning Act of 1974 (88 Stat. 476), as amended by the National Forest Management Act of 1976 (90 Stat. 2949) specifies that an interdisciplinary approach will be used in the management of national forest lands. These acts require an integration of planning for all uses including the timber, range, fish and wildlife, water, and other resources. Regarding the wildlife resource, the proposed rules call for inventory of existing wildlife, collection of quantitative data on species and community diversity, and relationship of wildlife population trends to habitat changes resulting from management practices (Federal Register Vol. 43, No. 170, 1978).

The Tongass National Forest has addressed the various forest uses and management planning alternatives in the "Southeast Alaska Area Guide" of 1977 and the 1978 draft environmental statement of the "Tongass Land Management Plan." The goal is to produce a comprehensive land management plan that will strike a balance between the many uses of Tongass National Forest and preservation of its unique values (USDA Forest Service 1978).

Nongame forest bird species need to be addressed in the resource inventory process of Tongass National Forest. A preliminary census of birds in logged and unlogged hemlock/spruce forest was conducted by Noble (1977). Forestry practices affect bird populations by bringing about major and long-lasting habitat changes. Timber management and vegetation succession effects on bird communities have been reported for various forest types including the Piedmont region of Georgia (Johnston and Odum 1956), coniferous forests of northwestern California (Hagar 1960), the forests of Finland (Haaparen 1965), four forest types in Virginia (Hooper 1967), the pinehard-wood forests of Texas (Thornburgh 1967, Michael and Thornburgh 1971), the hardwood and Conifer forests of Virginia (Conner et al. 1975), the conifer forests of Oregon and Washington (Thomas et al. 1976), and the northern hardwood forests of New York's Adirondack Mountains (Webb et al. 1977).

Clearcutting is practiced as the silvicultural system most appropriate to the economic and biological situation of southeast Alaska (Harris and Farr 1974). Clearcutting dramatically alters the structural nature of the forest environment. Vegetation structural features are recognized as the major determinants of habitat occupancy and use by bird species (Pitelka 1941, MacArthur et al. 1962, Zeedyck and Evans 1975, Balda 1975, and many others).

In 1978 a study was undertaken to evaluate clearcutting effects on habitat structure and forest bird species of the Tongass National Forest. Specific objectives were as follows:

1. Determine the presence of breeding bird species in stands of old-growth timber and in clearcuts of various successional stages.
2. Estimate the relative densities of breeding bird species in these representative areas.
3. Monitor changes in bird species diversity in relation to post-logging vegetation changes.
4. Describe bird species replacement which occurs as succession proceeds in logged areas.
5. Identify indicator bird species which show positive, negative, or neutral responses to clearcutting.

Acknowledgements

Special thanks go to Mr. Paul Harrington, USDA Forest Service, Ketchikan, Alaska, for his generous assistance throughout all phases of the study. Mr. Dave Garber, USDA Forest Service, Ketchikan, and Dr. William Farr, USDA Forest Service, Juneau, Alaska, are gratefully acknowledged for their comments.

The excellent and enthusiastic assistance provided by my field partner, Mr. Tom Kugut, USDA Forest Service, Craig, Alaska, was indispensable to the field portion of the study. Sincere thanks are extended to Tom Kogut and to his supervisor, Mr. Len Brady, who was willing to "loan" his field assistant for the duration of the field work.

This study was made possible by the Faculty Exchange Program of the USDA Forest Service.

Study Area

The study was conducted in the southwest portion of Kosciusko Island (fig. 1). The base camp, Cape Pole, is located about 161 km northwest of Ketchikan, The approximate coordinates of Cape Pole are 55¼58'N and 133¼47'W. Elevational range of Kosciusko Island is primarily sealevel to 150 m, with a few peaks up to 300 m. Soils are young, thin, and largely derived from Pleistocene glacial till (Harris et al. 1974).

Much of the southwest portion of Kosciusko Island has been clearcut, resulting in a mosaic of regenerating forest stands. These successional stands include recent clearcuts and older cuts up to about 30 years of age. Interspersed with these clear-cuts are muskegs and remnant old-growth forest. The forests are primarily western hemlock (Tsuga heterophylla) and Sitka Spruce (Picea sitchensis), with lesser occurence of western redcedar (Thuja plicata) and Alaska-cedar (Chamaecyparis nookatensis). Muskegs are bog communities dominated by sphagnum mosses, sedges and rushes and ericaceous shrubs. Most of the northeast portion of Kosciusko Island is presently uncut and is vegetated by old-growth forests and muskegs.

The climate of southeast Alaska is maritime. Normal summer temperatures range from 5¼C (USDA Forest Service 1978). In winter, the temperature ranges from about -10¼ to 5¼C. Considerable precipitation occurs throughout the year. Temperature and rainfall conditions for May-July 1978 (table 1) were typical for the Cape Pole area (U.S. Dept. Commerce 1978). No climatological data were recorded at the Cape Pole weather station during August.

Table 1--Mean maximum temperature, mean minimum temperature, and total rainfall during May, June, and July 1978 at the Cape Pole weather station, Alaska.

	Temperature		
Month	Mean Maximum	Mean Minimum	Rainfall
	¼C	¼C	¼C
May	10.6	4.0	20.0
June	13.2	8.1	5.4
July	(1/)	9.1	6.4

1/ Data not available.

Methods

Stand Selection

Six stages of vegetational growth were selected to represent successional development on western hemlock/Sitka spruce timber sites. (Throughout this report the six successional stages will be referred to as "types.") These vegetational types, and their approximate ages, are as follows:

1. Recent clearcut, less than 5 years;
2. Shrub/sapling, 11 years;
3. Sapling/shrub, 17 years;
4. Pole, 30 years;
5. Young sawtimber, 80 years; and
6. Old-growth.

Stand ages were determined by annual ring counts. Trees in the oldgrowth type were not aged. Old-growth sawtimber in the Tongass National Forest is defined as timber over 150 years of age (USDA Forest Service 1978). However, it is likely that most of the trees within the old-growth type were considerably older.

Successional vegetation in the recent cuts and in the 11,17, and 30-year types resulted from clearcutting operations. No harvested stands exceeding 30 years of age were present on Kosciusko Island. However, a large (9 ha) stand of even-aged, 80 year old timber was present, apparently the result of windthrow (William Farr, USDA Forest Service pers. comm.). Stephans and others (1969) reported that forest regeneration rates on blowdowns are slower than on burned or logged stands of comparable age. However, this stand was included as the closest available approximation to a clearcut in the young sawtimber stage of succession.

Where possible, replicate stands were selected for each of the six types. All selected stands contained a minimum of 8 ha of grossly uniform vegetational cover. Replicate stands were separated by at least 2km. Replicate stands for the 20 and 80 year types were not available on the study area.

Transect Placement

Relative bird densities in all stands were estimated by a modified line transect method (Conner and Adkisson 1975). Absolute density methods were rejected as unsuitable for the extremely dense vegetation of the area (Noble 1977). Relative density estimates are appropriate for evaluating differences between treated areas and/or years (Webb et al. 1977).

Four 300 m transects were established in each stand. The entire length of each transect was at least 50 m within the homogeneous stand and came no closer than 50 m to any other transect. Skid trails and narrow logging roads were utilized, where possible, to facilitate movement through dense successional vegetation. Old-growth transects were placed along random compass bearings.

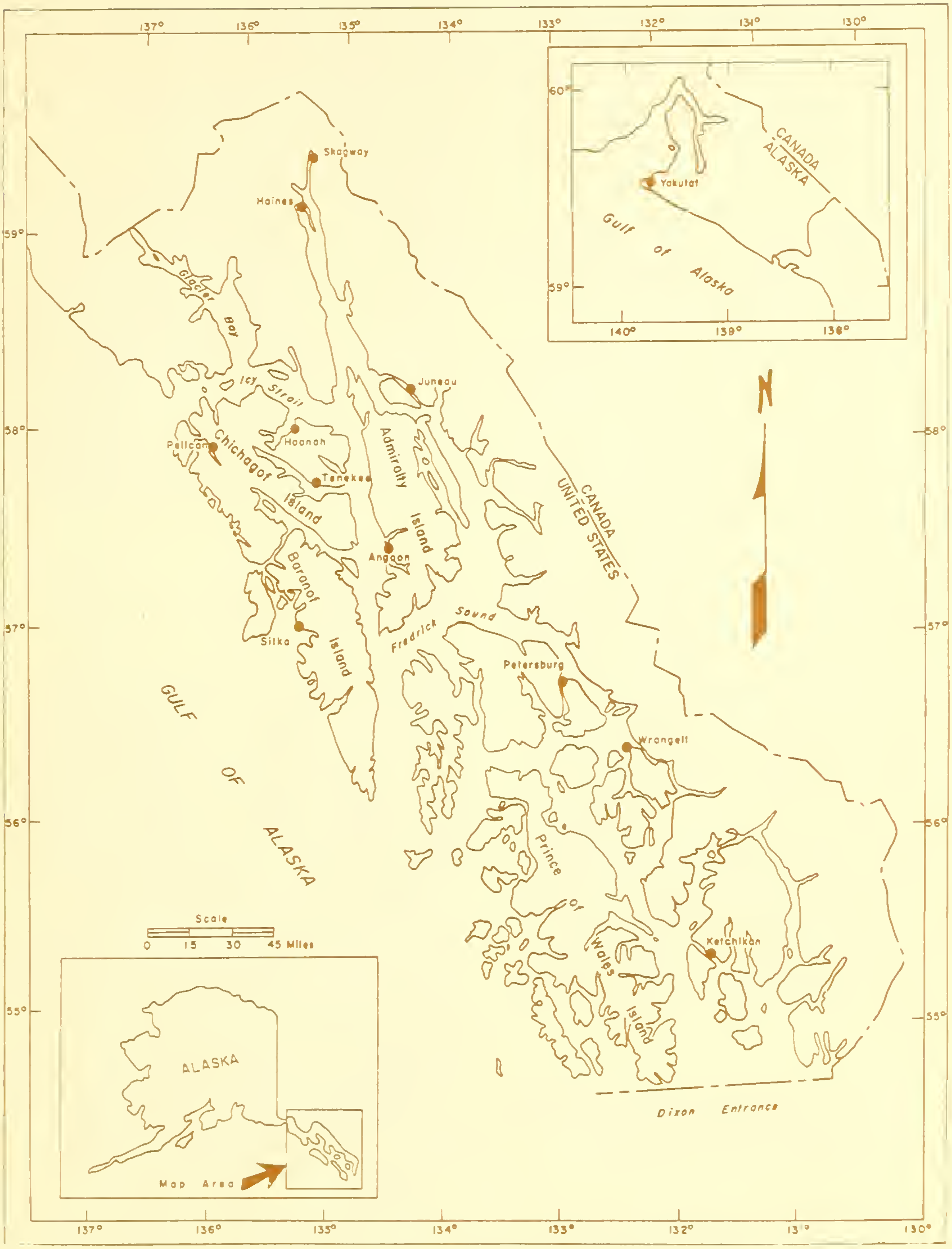

Figure 1 -- Map of southeast Alaska east of the 141st meridan.

Bird Sampling

Bird data were collected from 30 May to 17 July 1978. Each stand received four morning and eight evening visits. Stand visits were spaced over the 7 week sampling period to minimize bias because of waning breeding season activity. Morning and evening visits were evenly divided between the two observers to minimize observer bias. Bird sampling was not conducted during rainy periods or when wind velocity exceeded about 20 kph. There conditions are known to decrease bird activity and bias bird census data (Webb et al. 1977).

Morning sampling began 30 min after sunrise, and evening sampling was initiated 2 hours and 30 minutes before sunset. Time required to complete each stand varied from 2.5 to 4.0 hours, according to difficulty of terrain and distance from roads.

Observers worked individually and walked slowly along transects. Five-minute stops were made at stations located at 20 m intervals. This procedure provided 20 stations per stand. All birds located within 40 m of the transect were recorded, along with the following information: 1) stand, transect, and station number; 2) sex and age,if known; 3) how bird was observed (seen, heard, or both): 4) substrate; 5) activity; 6) number of birds in group. (Throughout this report "sightings" and "observations" will refer to birds recorded within this 40 m strip, unless otherwise indicated.) These data were coded directly onto prepared data forms. The same information, where possible, was recorded for birds observed outside the 40 m strip. Only sightings recorded within the 40 m strip were used for relative density estimates. However, the additional sight records were kept to provide information on rarer species that might otherwise have been missed. Climatological data including temperature, wind velocity, and cloud cover were recorded at the start of each sample period.

Bird observations for each transect were summed over the eight visits. All species recorded at least twice in a given type were included in the data analysis for that type. Single sightings were tested for statistical differences by analysis of variance and Duncan's multiple range test (Steel and Torrie 1960). Bird abundance data in this report are expressed as Population Index (PI) values. PI is defined as the mean number of bird observations per transect per visit.

Vegetation Sampling

Four 100 m vegetation transects were established in each stand. Transect starting points were randomly located along the bird transects. Transect directions were determined by random compass bearings.

Percentage of cover of understory species was ocularly estimated within ten 0.001 ha circu-lar plots placed along each transect. The herbaceous and shrub layers were sampled separately. The 0.0001 ha plots were also used for estimation of tree seedling den-sities. Herbaceous and shrub data were summed over plots to provide estimates of percent cover and percent frequency (percent of plots in which the species occurred) for each transect. Mean cover and frequency values were tested for differences by analy-sis of variance and Duncan's multiple range test.

Trees in the shrub/sapling, sapling/shrub, and pole types were sampled by the point-centered-quarter (PCQ) method (Cottam and Curtis 1956). Height and density data were obtained for 80 trees in each stand. Tree measurements (height, DBH, and diameter at 4.9 m) on young sawtimber and old-growth stands were obtained by plotless methods (Avery 1975).

Plotless technique was also used to obtain snag measurements on the young sawtimber stand. Snag characteristics in old-growth forests have been reported for Tongass National Forest by Noble (1978). Therefore, no snag data were collected for old-growth stands. On logged stands, low snag densities precluded use of PCQ technique for obtaining snag measurements. Density estimates on these stands were obtained by counting snags on paired 1977 color aerial photographs (1:7,920) using a reflecting stereoscope for snag identification.

Selected vegetation characteristics and bird abundance data were subjected to correlation analysis (Steele and Torrie 1960) for measurement of possible associations between variables.

Results and Discussion

Vegetation

Shrub Layer

All types except the 80-year sawtimber were characterized by a well-developed shrub layer (table 2). Mean total shrub cover was 26 percent of recent clearcuts and reached maximum values of 44 and 49 percent, respectively, in 11-and 17-year stands. Mean total shrub cover in the 30-year pole type was, at 39 percent, not significantly lower than the other successional stands. Understory shrubs in the 80-year type were very sparse, providing only 8 percent of cover. Old-growth understory was characterized by a well-developed shrub layer, providing 37 percent of cover.

Most shrub species occurred in all types. Exceptions were thimbleberry (Rubus pari-florus) and red elder (Sambucus callicarpa) which were associated with early to mid successional stages. Other important shrubs included blueberries (Vaccinium spp.), salmonberry (Rubus spectabilis), rusty menziesia (Menziesia ferruginea), devils-club (Echinopanax horridum), and currants (Ribes spp.). Relationship of individual species to successional stage are indicated by differences in percent cover (table 2) and percent frequency (table 3) values.

Table 2--Percentage of cover of shrub species in six stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years 1/					
Species	< 5	11	17	30	80	150±
Actea rubra	Ta	0a	0a	0a	0a	0a
Minziesia ferruginea	0.8a	2.2a	1.4a	0.7a	0a	0.3a
Echniopanax horridum	1.5b	1.8b	3.0ab	.4b	0.5b	7.3a
Ribes spp. 2/	1.1a	1.9a	3.5a	2.3a	0a	.9a
Rubus parviflorus	.2a	.9a	.5a	0a	0a	0a
Rubus spectabilus	6.3b	11.5ab	20.4a	19.6a	.9b	6.4b
Sambucus callicarpa	1.1a	.5a	3.6a	1.0a	0a	Ta
Vaccinium spp. 3/	14.8bc	25.1a	17.7ab	14.9abc	2.9c	21.6ab
Total	25.9c	43.7ab	49.4a	38.9abc	4.2d	36.6bc

T = Trace; less than 0.1 percent.

1/ Means followed by the same letter are not different (P - 0.05) as determined by Duncan's multiple range test.

2/ R. bracteosum and R. laxiflorum.

3/ V. Alaskaense, V. ovalifolium, and V. parvifolium.

Table 3--Percentage of frequency of shrub species in six stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years 1/					
Species	<5	11	17	30	80	150+
		Percent				
Actea Rubra	1.2a	0a	0a	0a	0a	0a
Menziesia ferruginea	17.5b	41.2a	18.7b	15.0b	0b	5.0b
Echinopanax horridum	31.2ab	17.5b	13.7b	10.0b	12.5b	51.2a
Ribes spp. 2/	20.0ab	20.0ab	33.7a	17.5ab	0b	8.7b
Rubus parviflorus	5.0a	1.2a	2.5a	0a	0a	0a
Rubus spectabilus	67.5a	76.2a	76.2a	85.0a	15.0b	41.2b
Sambucus callicarpa	23.7a	7.5b	11.2b	15.0ab	0b	2.5b
Vaccinium spp. 3/	93.7a	96.2a	76.2b	77.5ab	52.5c	90.0ab

1/ Means followed by the same letter are not different (P = 0.05) as determined by Duncan's multiple range test.

2/ R. bracteosum and R. laxiflorum

3/ V. alaskaense, V. ovalifolium, and V. parviflorum.

Herbaceous Layer

Mean values for total herbaceous cover were less variable among types than were similar values for shrub cover (table 4). The herbaceous layer was best developed (25%, 30%) in recent clearcuts and old-growth stands. Minimum herbaceous cover (8%) characterized the 30-year pole type. Intermediate values, ranging from 14 to 16 percent, resulted for 11-, 17-, and 80-year stands. Fern species collectively contributed at least 25 percent of total herbaceous cover in all types. The herbaceous layer of 80-year and old-growth timber types was underlain by a dense moss carpet.

Individual species associations with successional stages are indicated by differences in percentage of cover (table 4) and percentage of frequency (table 5) values.

Table 4--Percentage of cover of herbaceous vegetation in six stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by year 1/					
Species	< 5	11	17	30	80	150+
		Percent				
Ferns 2/	7.7a	5.9a	8.6a	5.5a	8.6a	7.3a
Coptis aspenifolia	.8b	.6a	.1b	T	.2b	3.3a
Cornus canadensis	7.6a	4.4b	1.0c	.9c	.2c	1.8bc
Epilobium glandulosum	1.0a	Tb	Tb	.2b	0b	0c
Listera cordata	0b	0b	0b	0b	.2b	1.2a
Lysichiton americanum	.3a	.2a	0a	0a	0a	0a
Maianthemum dilatatum	.3bc	1.1b	2.8a	.4bc	.5bc	Tc
Moneses uniflora	0b	0b	0b	0b	1.0a	.8a
Rubus pedatus	5.6ab	2.4b	1.6b	.6b	.4b	8.1a
Streptopus spp 3/	.3b	Tb	Tb	0b	.2b	2.6a
Tiarella trifoliata	1.3ab	.1b	.4b	.4b	2.0a	2.6a
Vaccinium caespitosum	0.2b	0.1b	0.2b	0.2b	0.7a	0.9a
Veratrum viride	Ta	Ta	0a	0a	0a	0a
Viola glabrata	.2b	0b	Tb	Tb	0b	0.9a
TOTAL	25.2a	15.0ab	14.6b	8.3b	14.0b	29.5a

T = Trace; less than 0.1 percent.

1/ Means followed by the same letter are not different (P = 0.05) as determined by Duncan's multiple range test.

2/ Adiantum pedatum, Athyrium filix-femina, Blechnum spicant, Dryopteris dilatata, Gymnocarpium dryopteris, Polypodium vulgare, and Polystichum munitum.

3/ S. amplexifolius, S. roseus, and S. streptopoides.

Table 5--Percentage of frequency of herbaceous vegetation on six successional stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years 1/					
Species	< 5	11	17	30	80	150+
		Percent				
Coptis aspenifolia	36.2b	23.8b	6.2c	2.5c	5.0c	67.5a
Cornus canadensis	78.7a	65.0ab	17.5d	22.5cd	5.0d	43.8bc
Epilobium glandulosum	45.0a	2.5b	2.5b	10.0b	0b	0b
Listera cordata	0c	0c	0c	2.5c	20.0b	46.2a
Lysichitum americanum	7.5a	3.7a	0a	0a	0a	0a
Maianthemum dilatatum	13.7bc	31.2b	53.7a	15.0bc	17.5bc	2.5c
Moneses uniflora	0b	0b	0b	0b	47.5a	31.2a
Rubus pedatus	80.0a	66.2a	23.7b	30.0b	10.0b	83.7a
Streptupus spp 2/	16.2b	1.2b	1.2b	0b	17.5b	77.5a
Tiarella trifoliata	45.0a	6.2b	12.5b	12.5b	50.0a	48.7a
Vaccinium caespitosum	6.2b	6.2b	11.2b	10.0b	42.5a	32.5a
Veratrum viride	1.2a	2.5a	0a	0a	0a	0a
Viola glabrata	2.5b	0b	2.5b	2.5b	0b	20.0a

1/ Means followed by the same letter are not different (P = 0.05) as determined by Duncan's multiple range test.

2/ S. amplexifolius, S. roseus, and S. streptopoides.

Tree Layer

Tree regeneration was very dense in all successional stands. Seedlings densities of 5,500/ha occurred on the shrub and forb dominated recent clearcuts (table 6). High sapling densities (6,158/ha) in 11-year stands, in combination with dense shrub development, created a nearly impenetrable layer around 2 m deep. Saplings in the 17 year stands were likewise closely spaced, at 3,240/ha, but they had overgrown the shrub layer. Mean tree height was 3.8 m, and some canopy closure was evident. Pole-size trees of the 30-year type averaged 6.7 m in height. Canopy closure in this type was essentially complete.

The two forested types were characterized by similar basal area values (48-51 m^2/ha), but differed in tree size, density, and composition (tables 7 and 8). Most trees in the 80-year type were less than 70 cm DBH and, at 161/ha, were closely spaced. The dense canopy provided by these trees permitted little sunlight into the understory. A few trees representing larger size classes had survived the windthrow which created the stand. Mean DBH and density in the old-growth type were 92 cm and 114/ha, respectively.

Snags were abundant in the 80-year type, and represented two extreme size classes (table 7). Components of the larger (F85 cm DBH) size class were remnants of the pre-blowdown forest whereas the smaller (15-39 cm DBH) snags represented tree regeneration since the blowdown. Presence of the larger snags in this 80-year stand would not be representative of a logged forest of comparable age.

Snags were practically lacking on recent clearcuts and scarce (0.17/ha) on 11-year cuts due to existing snag-removal policy on the Tongass National Forest. Snags were somewhat more abundant on older clearcuts. Estimated densities of 0.65/ha occurred on the 11-year stands and 0.62/ha in the 30-year type.

Table 6--Mean density, mean height, mean DBH, mean basal area, and species composition of trees in six successional stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years 1/					
Stem	<5	11	17	30	80	150+
Size class considered	Seedling	Sapling	Sapling	Pole	Sawtimber	Sawtimber.
Density (stems/ha)	5,500	6.158	3,240	4,047	161	114
Height (M)	(F0.5)	2.06	3.79	6.723	3.93	4.2
DBH (cm)		(F13)	(F13)	(13-30)	50.99	2.2
Basal area (m^2/ha)					50.54	7.7
Species composition (percent):						
Western hemlock	78.9	55.1	46.5	46.3	54.08	4.5
Sitka spruce	15.0	44.9	52.5	53.7	46.01	5.5
Western redcedar and Alaska-cedar	6.1	0	T	0	0	0

1/ Values in parentheses are estimated ranges for variables which were not sampled.

Table 7--Size class distribution (5) of tree species and snags in old-growth hemlock/spruce forest, Kosciusko Island, Alaska

	DBH class (cm)						
Stem	10-49	50-89	90-114	115-139	140-164	Over 165	Total
				Percent			
Western hemlock	5	37	18	8	0	0	68
Sitka spruce	2	4	10	5	9	2	32
Total	3	35	36	13	10	3	100
Snags	0	30	23	6	41	0	100

Table 8--Size class distribution of tree species and snags in old-growth hemlock/spruce forest, Kosciusko Island, Alaska

	DBH class (cm)					
Stem	15-39	40-54	55-69	70-84	Over 85	Total
				Percent		
Western hemlock	25	9	11	5	0	48
Sitka spruce	9	16	20	5	2	52
Total	32	25	31	10	2	100
Snags	71	0	0	0	20	100

Bird Fauna

Faunal Composition

Twenty-one species were represented in the bird data (table 9). The six most abundant species collectively comprised 75 percent of total observations. These species included the winter wren (Troglodytes troglodytes), orange-crowned warbler (Vermivora celeta), dark-eyed junco (Junco oreganus), chestnut-backed chickadee (Parus rufescens), golden-crown kinglet (Regulus satrapa), and fox sparrow (Paserella iliaca).

Faunal composition varied among types due to individual species responses. Fifteen of the 21 species had Population Index (PI) values that differed significantly (P = 0.05) by type.

The winter wren was the most common species and occurred in all stands sampled. Winter wren abundance peaked (PI = 1.89) on recent clearcuts, where the species con tributed 58 percent of total PI. Winter wren PI values for all other types ranged from 0.84 to 1.06, and were not significantly different from one another (fig. 2).

Dark-eyed juncos were most abundant in early successional stands. The species contributed about 25 percent of total PI on recent clearcuts and 11-year stands. Dark-eyed junco PI values on these stands were 0.84 and 1.04, respectively. Similar abundance (PI = 0.94) occurred in 17-year stands, but in the 30-year pole type the population was about 50 percent lower. No dark-eyed juncos were recorded in the 80-year type. The species occurred in old-growth stands with a PI of 0.19.

The orange-crowned warbler, fox sparrow, Swainson's thrush (Hylocichla ustulata), Stellar's jay (Cyanocitta cristata), and ruby-crowned kinglet (Regulus calendula) showed similar abundance peaks in midsuccessional (11; 17; and 30-year) stands. The orange-crowned warbler was the most common species in the 17-and 30-year stands. All of the five midsuccessional species were absent from the 80-year types. Only the orange-crowned warbler was recorded in old growth, and at a lower PI value (0.42) than in the midsuccessional types.

The robin (Turdus migratorius) was observed almost exclusively in the 30-year type. In contrast, the hermit thrush occurred in all types. Peak hermit thrush abundance occurred in 30-year vegetation (PI =0.47) and in old growth (PI = 0.33). The varied thrush was absent from recent clearcuts, scarce (PI = 0.08) in 11-year stands, and peaked (PI = 0.28) in old-growth stands.

Four species were absent from early successional stages and reached highest PI values in forested stands. The golden-crowned kinglet was infrequently observed (PI = 0.08) in 17-year vegetation. Abundance was maximum (PI = 1.44) in 80-year sawtimber, and contributed 38% to total PI. The chestnut-backed chickadee was absent from recent clearcuts and 11-year stands, but was common (PI =0.58-0.88) in all older types. The western flycatcher (Empidonax difficilis) occurred in stand 30 years and older. Sightings of Wilson's warbler (Wilsonia pusilla) were rare and restricted to old-growth stands.

Six species had very low PI values for which no significant differences (P = 0.05) between types were detected. These species were recorded 10 or fewer times. The sharp-shinned hawk (Accipiter striatus) and yellow-bellied sapsucker (Sphyrapicus varius) were recorded only in old-growth stands. However, both species were seen in recent clearcuts adjacent to old-growth stands. Recorded hairy woodpecker (Dendro-copos villosus) observations were restricted to one recent clearcut stand. A pair was nesting in a snag within the clearcut.

Song sparrow (melospiza melodia) observations were rare and restricted to 11-year (PI = 0.13) and 17-year (PI = 0.03) stands. Occurrence of the species was limited to specific areas and may have been associated with the presence of water.

Tree swallow (Oridoprocne bicolor) and common raven (Corvus corax) observations in certain successional stands were mostly of birds perched on snags or in flight. These species were known to be nesting primarily in habitats other than those under study and were therefore not regarded as representative of the stands in which they were recorded.

Other species observed within the sampling stands were excluded from the data by the time or space restrictions of the sampling procedure. Goshawks (Accipiter gentilis) and red-tailed hawks (Buteo jamaicensis) were observed hunting in recent and early-successional clearcuts. Several sightings of merlin (Falco columbarius) and willow ptarmigan (Lagopus lagopus) occurred in 17-year stands. The rufous hummingbird (Sel-asphorus rufus) was observed feeding in 11-and 17-year stands. Single sightings of a pine grosbeak (Pinicola enucleator) and a pair of band-tailed pigeons (Columba fasciata) were noted in the 17-year vegetation. A single observation of the red-breasted nuthatch (Sitta canadensis) was recorded in old-growth stands.

PI values were summed over species for comparison of total bird abundance among types (table 9). Minimum total PI occurred on recent clearcuts (fig. 2). Greatest bird abundance was encountered in 16-and 30-year stands, where total PI values significantly (P = 0.05) exceeded all other types.

Diversity

The Shannon-Weaver Index (H') was used to compare avian diversity among types (Shannon and Weaver 1949). This diversity measure incorporates both species richness (number of species) and the evenness with which the species are distributed in a community. Evenness of the bird fauna in each type was also expressed by an Equitability Index, which relates the diversity measure (H') to its maximum possible value (H max) for the total number and species of birds present (Pielou 1975, Peet 1974).

Lowest diversity and equitability measures characterized the avifauna of recent clearcuts (table 10). Only 8 species were recorded in these stands. The 80-year sawtimber type yielded only 7 species. However, more even distribution of species resulted in higher H' and H'/H max values than those of recent clearcuts. Highest diversity and equitability characterized the 30-year pole type, where 14 species were recorded. Intermediate values resulted for 11-year, 17-year, and old-growth stands.

Table 9--Population index (number/transect/visit), relative rank, number observed, and species rank for 21 bird species observed during summer 1978 in six stages of hemlock/spruce forest Kosciusko Island, Alaska

Species	Stand age by years												Number of birds observed	Species rank
	<5		11		17		30		80		150+			
	PI	Rank	PI	Rank	PI	Rank	PI	Rank	PI	Rank	PI	Rank		
Winter wren	1.89	1	0.97	2	1.06	2	0.84	3	0.91	2	0.91	1	365	1
Orange-crowned warbler	.06	5	.86	3	1.38	1	1.03	1	0		.42	5	207	2
Dark-eyed junco	.84	2	1.04	1	.94	3	.44	6	0		.19	8	206	3
Chestnut-backed chickadee	0		0		.58	5	.88	2	.66	3	.78	3	136	4
Golden-crowned kinglet	0		0		.08	11	.13	13	1.44	1	.86	2	110	6
Fox sparrow	.03	7	.63	4	.86	4	.63	4	0	0			117	5
Hermit thrush	.08	4	.17	5	.17	8	.47	5	.16	5	.33	6	68	7
Townsend's warbler	0		0		0		.16	12	.44	4	.75	4	67	8
Varied thrush	0		.08	7	.17	8	.19	11	.09	6	.28	7	43	9
Stellar's jay	.05	6	.13	6	.23	7	.37	8	0		0		38	10
Swainson's thrush	0		.03	8	.33	6	.34	9	0		0		34	11
Ruby-crowned kinglet	0		0		0.11	10	0.41	7	0		0		20	12
Western fly-catcher	0		0		0		.19	11	0.16	5	0.13	9	19	13
Tree Swallow	0.17	3	0.17	5	.13	9	0		0		0		30	14
American Robin	.05	6	0		0		.25	10	0		0		11	15
Song Sparrow	0		.13	6	.03	12	0		0		0		10	16
Wilson's Warbler	0		0		0		0		0		.05		103	17
Common Raven	.05	6	0		0		0		0		.03		3	17
Yellow-bellied sapsucker	0		0		0		0		0		.03		112	18
Hairy woodpecker	.03	7	0		0		0		0		0		2	18
Sharp-skinned hawk	0		0		0		0		0		.03		112	18
TOTAL	3.25		4.21		6.07		6.33		3.86		4.73		1,493	--

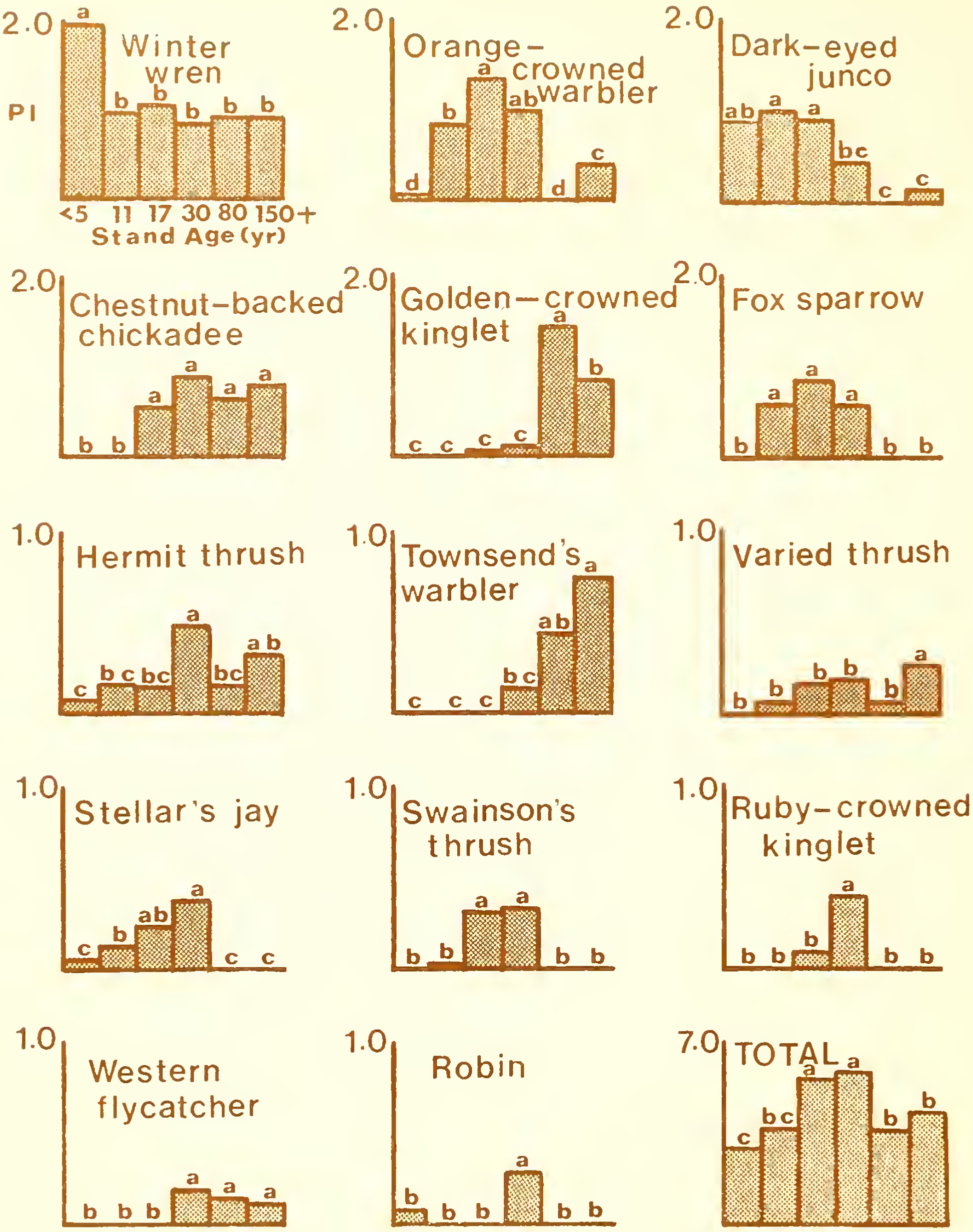

Figure 2.--Population (PI) levels of the 14 most common species and total population (PI) levels of birds observed in six stages (F5 yr, 11 yr, 17 yr, 30 yr, 80 yr, 150+ yr) of hemlock/spruce forest during summer 1978, Kosciusko Island, Alaska. PI values designated by the same letter are not different (P = 0.05) as determined by Duncan's multiple range test.

The apparent pattern of bird diversity response to post-logging succession is an increase over time to some point between the pole and young sawtimber stages. Diver-sity is depressed during the young maturity. Studies conducted in various forest types have reported a general pattern of increasing bird species diversity as forest succession advances toward maturity (Johnson and Odum 1956, Wiens 1975, Edgarton and Thomas 1978). In some situations, maximum diversity occurs when climax vegetation is restored (Odum 1950, Martin 1960). Other studies have yielded results, similar to the Kosciusko Island situation, indicating maximum bird species diversity during some stage of succession (Kendeigh 1946, Karr 1968). The pattern is generally attributed to structural complexity of the vegetation during succession (Balda 1975). In the spruce/hemlock forests of southeast Alaska the sapling, pole, and old-growth stages are structurally complex due to the well-developed status of the tree, shrub, and herbaceous layers. The young sawtimber stage, represented in this study by the 80-year old stand, is structually simple due to restriction of understory development by the dense tree canopy. The duration of this stage is unknown; however, conditions of low avian diversity and abundance may be expected to prevail.

Table 10--Shannon-Weaver diversity and equitability of bird species in six stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years					
	<5	11	17	30	80	150+
Species (No.)	8	10	13	14	7	11
Diversity (H')	1.273	1.875	2.153	2.455	1.611	2.117
Equitability (H'/H max)	.553	.814	.839	.930	.828	.834

Community Overlap

Horn's Index of Similarity (Ro), a derivative of the Shannon-Weaver formula, was used to measure species overlap between types (Horn 1966). Ro values range from 0 when two samples have no species in common to 1 when the samples are identical with respect to proportional species composition.

Minimum overlap occurred between 80-year sawtimber and all earlier successional stages (table 11). The bird faunas of recent clearcuts, 11-, 17-, and 30-year stands were more similar to old-growth faunas than to those of the 80-year type. Bird faunas of successive ages showed a trend of increasing similarity to old-growth stands. This range of old-growth Ro values went from 0.47 for recent clearcuts to 0.88 for the 80-year sawtimber type.

Table 11--Horn's Ro for bird species in six stages of hemlock/spruce forest, Kosciusko Island, Alaska

	Stand age by years					
Stand age by years	<5	11	17	30	80	150+
F5	1.00	0.75	0.65	0.53	0.33	0.47
11		1.00	.92	.75	.33	.57
17			1.00	.90	.41	.63
30				1.00	.54	.72
80					1.00	.88
150+						1.00

Bird species composition and proportional distribution for the six types are graphically summarized in figure 3.

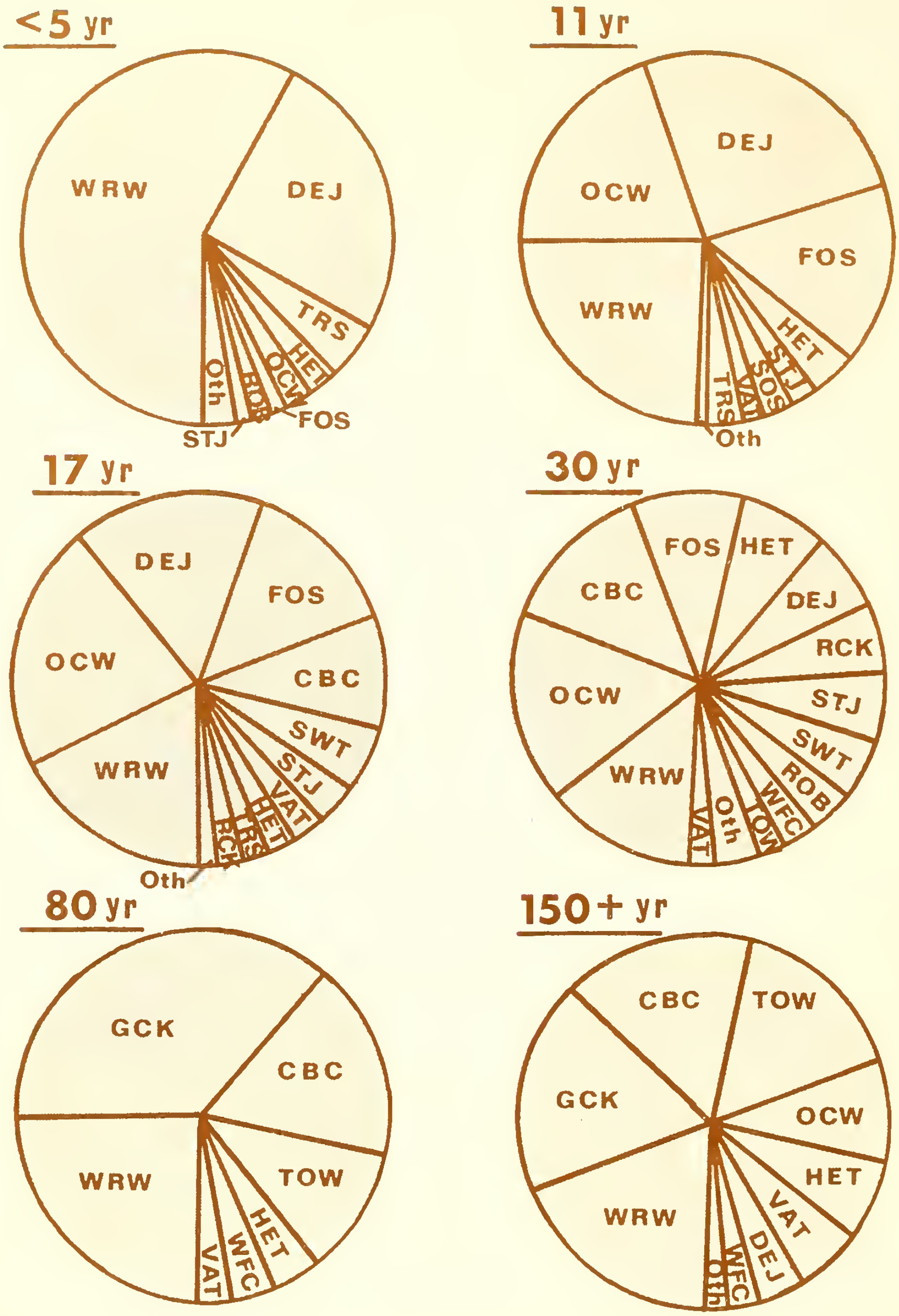

Figure 3.--Proportional distribution of bird species observed during summer 1978 in six stages of hemlock/spruce forest, Kosciusko Island, Alaska. (Abbreviations are winter wren (WRW), orange-crowned warbler (OCW), dark-eyed junco (DEJ), chestnut-backed chickadee (CBC), golden-crowned kinglet (GCK), fox sparrow (FOS), hermit thrush (HWT), Townsend's warbler (TOW), Stellar's jay (STJ), Swainson's thrush (SWT), ruby-crowned kinglet (RCK), western flycatcher (WFC), tree swallow (TRS), American robin (ROB), song sparrow (SOS), and others (oth).)

Functional Responses

The life form system of Thomas and others (1979) was used to classify observed bird species according to their habitat orientation for feeding and reproduction (table 12). This system identifies species assemblages of birds affected by habitat alteration and allows prediction of logging impacts (Meslow 1978). The life form system was applied to the Kosciusko Island data to relate altered habitat characteristics to species functional requirements and to test the predictive potential of the system for South-east Alaskan forest birds.

Life forms 5, 6, and 7, representing species oriented to ground and shrub substrates, were significantly more abundant (P F 0.05) on early to midsuccessional stages (table 13). Mean PI values for the three groups were positively correlated (r = 0.41, 0.53, and 0.45; P = 0.0008, 0.0004, and 0.003, respectively) with total percentage of shrub cover. Life form relationships to type were in accordance with individual component species responses, except for the Wilson's warbler. This species was observed only in old-growth stands. Low number of observations and possible association with water prohibit conclusive statements on Wilson's warbler responses to clearcutting.

Table 12--Life form designations and reproduction and feeding orientation of bird species observed in logged and unlogged hemlock/spruce forests, Kosciusko Island, Alaska 1/

Life form	Substrate orientation		
number	Reproduction	Feeding	Species
5	On ground without specific water, cliff or talus association	On ground.	Dark-eyed junco, Hermit thrush, Wilson warbler.
6	On ground.	In bushes, trees, or air.	Orange-crowned warbler, Winter wren.
7	In bushes.	On ground, in water or air.	Fox sparrow, Song sparrow, American robin. Swainson's thrush.
10	Primarily in conifers.	In bushes, trees, or air	Western flycatcher, Golden-crowned kinglet, Ruby-crowned kinglet, Townsend's warbler.
11	In trees.	On ground in bushes, trees, or air.	Stellar's jay, Varied thrush, Sharp-skinned hawk.
13	Excavates own hole in a tree.	On ground, in bushes, trees or air.	Hairy woodpecker, Yellow-billied sapsucker.
14	In a hole made by another species or naturally occurring.	On ground or in water or air.	Chestnut-backed chickadee.

1/ Life form descriptions and species designations are from Thomas and others (1979).

Table 13--Populations Index (PI) for 7 life forms represented by birds observed in six stages of hemlock/spruce forest, Kosciusko, Island, Alaska 1/

Life form	Stand age by years					
	< 5	11	17	30	80	150+
5	7.38ab	9.63a	8.88a	7.25ab	1.25c	4.50bc
6	15.63ab	14.63bc	19.50a	15.00bc	7.25d	10.63cd
7	.63b	6.25a	9.75a	9.75a	0c	0c
10	0c	0c	1.50c	7.00b	16.25a	13.88a
11	.38d	1.63bcd	3.25ab	4.50a	.75cd	2.50abc
13	.25a	0a	0a	0a	0a	.25a
14	0b	0b	4.63a	7.00a	5.25a	6.25a

1/ PI values followed by the same letter are not significantly different (P=0.05) as determined by Duncan's multiple range test.

Life form 10, representing species oriented to coniferous trees, was significantly more abundant (P = 0.05) on older types having well-developed tree layer. A significant negative correlation (r =-0.046, P = 0.003) with total shrub cover was assumed to be a reflection of the negative effect of canopy closure on shrub development rather than an association between shrub cover and bird habitat selection.

Life form 11 species reached maximum abundance on mid successional stands having both well-developed tree and shrub layers. A positive correlation (r = 0.27) between shrub cover and bird abundance was not significant (P = 0.09). Life form 11 was poorly represented in types lacking either a tree canopy (early successional stands) or shrub development (80 year sawtimber).

Results for life form 13, representing the primary cavity excavators, were nonsignificant and inconclusive because of low numbers of woodpecker observations. Special habitat requirements of this group are discussed in a later section.

Life form 14, the secondary cavity users, consisted solely of the chestnut-backed chickadee. Old growth has been suggested as critical habitat for the species (Noble 1977) due to its requirement for suitable nesting cavities. The chestnut-backed chickadee was equally abundant in mid to late successional stands and old growth. These stands were characterized by a minimum snag density of 0.62/ha.

The chestnut-backed chickadee was absent from the newer clearcuts from which all snags had been removed. These results indicate that midsuccessional clearcuts may be used if suitable nesting sites are retained.

Observed numerical responses and known functional relationships of the recorded species were used as a basis for characterizing the effects of existing clearcutting practices in southeast Alaska forests (table 14). Species increased by logging are those whose population levels in one or more stages of forest succession significantly exceeds population levels in old growth. Species decreased by logging are absent or rare in successional stands or are known to require some habitat component of old-growth forest. Species for which the present study provides insufficent data are designated as inconclusive.

Special Habitat Needs

Old Growth

For some bird species old growth is considered an optimum if not essential habitat (Bull 1978). Some of these species, such as the Townsend's warbler, were commonly observed in old-growth stands of Kosciusko Island. Other old-growth dependent species may be present but remain unrecorded due to low densities or nocturnal habits. A partial listing of these species includes the goshawk (Accipiter gentilis), screech owl (Otus asio), great horned owl (Bubo virginianus), pygmy owl (Glaucicium gnomea), great gray owl (Strix nebulosa), hawk-owl (Surnia ulula), boreal owl (Aegulius funereus), saw-whet owl (Aegulius acadius),(a road-killed saw-whet owl was found on Kosciusko Island during the study, confirming the presence of the species), downy woodpecker (Dendropcopus pubescens), northern three-toed woodpecker (Picoides arcticus), boreal chickadee (Parus hudsonicus), red-breasted nuthatch (Sitta canadensis), and brown creeper (Certhia familiaris). Most of these old-growth dependent species are cavity nesters. Snags represent an essential habitat component provided by old-growth forests.

Noble (1978) has quantitatively evaluated the snag component of southeast Alaskan old-growth forests. His findings provide a needed data base for incorporating snag dependent species into forest management. Allocation levels of old-growth forest need to be prescribed for maintenance of desired levels of dependent species (Canutt and Poppino 1978, USDA Forest Service 1976).

Table 14--Effects of clearcutting on populations of bird species observed in logged and unlogged hemlock/spruce forest, Kosciusko Island, Alaska

	Bird species populations--	
Increased by clearcutting	Decreased by clearcutting	With inconclusive date to note change
Winter wren	Chestnut-backed chickadee	Tree swallow
Orange-crowned warbler	Golden-crowned kinglet	Wilson's warbler
Darkeyed junco	Townsend's warbler	Common raven
Fox sparrow	Varied thrush	Sharp-shinned hawk
Stellar's jay	Western flycatcher	
Swainson's thrush	Yellow-bellied sapsucker	
Ruby-crowned kinglet	Hairy woodpecker	
American robin		
Song Sparrow		
Hermit thrush		

Ecological Edge

The present study was designed to characterize habitat conditions and bird species responses on representative successional stages of spruce/hemlock forest. This objective required the confinement of observations to blocks of uniform habitat. Variation because of ecological edge and type interspersion was intentionally excluded.

These features of habitat must be considered in an evaluation of logging effects on forest bird populations. The significance of ecological edge to wildlife abundance and diversity is well documented (Leopold 1933, Kelker 1964, Thomas et al. 1978). The practice of clearcutting provides a mosaic of successional stages. The amount of ecological edge and horizontal diversity is a function of the size, shape, and placement of clearcuts. The habitat management potential of clearcutting has been stressed by Edgarton and Thomas (1978:64): "Evenage management gives land managers and biologists greater flexibility to produce stands of appropriate sizes and structural diversity to meet the varied needs for wildlife, including birds."

Riparian Zones

Riparian zones, or those areas influenced by water, are special habitats characterized by greater bird densities and diversities than adjacent areas without a water influence (Hooper 1967, Johnson 1970, Gill et al. 1974). The value of these unique habitats to birds may be seriously impaired by logging activities (Carothers et al. 1974, Bull 1978).

Field notes from the present study indicate affinity of some southeast Alaska bird species for riparian habitats. Table 15 is a partial listing of species observed in association with water influenced habitats.

Needed Research

Data on the special habitats is presently the most pressing research need for management of the forest birds on Tongass National Forest. Quantitative information is necessary for a comprehensive evaluation of logging effects on the forest bird fauna. The next phase of study should be designed to provide the following information:

1. Characterize the bird fauna of streamside corridors, muskeg, lakes, beach fringe, and other special habitats affected by logging practices.

2. Estimate relative densities of breeding birds in logged and unlogged special habitats.

3. Monitor changes in bird species diversity and population abundance resulting from alteration of special habitats.

4. Identify bird species which have critical requirements for one or more special habitats.

5. Integrate bird population data for clearcuts, successional stands, old-growth, and special habitats into a data framework for predicting logging effects on bird communities of Tongass National Forest.

Table 15--Partial listing of bird species observed in association with water influenced habitats, Kosciusko Island, Alaska

Species	Observed habitat
Common loon (gavia immer)	Stream
Trumpeter swan (Olor buccinator)	Muskeg lake
Bald eagle (Haliaeetus leucocephalus)	Beach fringe, stream
Sandhill crane (Grus canadensis)	Muskeg lake
Greater yellowlegs(Totanus melanoleucus)	Muskeg lake
Belted kingfisher (Megaceryle alcyon)	Stream
Common raven (Corvus corax)	Beach fringe
Northwestern crow (Corvus caurinus)	Beach fringe
Dipper (Cinclus mexicanus)	Stream
Lincoln's sparrow (Melospiza lincolnii)	Muskeg lake
Song sparrow (Melospiza melodia)	Streams, muskeg lake

Summary

Vegetation characteristics and bird populations in six stages of hemlock/spruce forest were studied during summer 1978 on Kosciusko Island, southeast Alaska. Vegetational stages, or types, included recent clearcut (less than 5 years old), shrub/sapling (11 years), sapling/shrub (17 years), pole(30 years), young sawtimber (80 years), and old-growth stands.

All types, except for 80-year sawtimber, were characterized by a well-developed shrub layer. Total herbaceous cover was less variable among types than was total shrub cover. Tree regeneration was very dense in all types. Mean tree height of 11-and 17-year saplings was 2.1 and 3.8 meters, respectively. Mean height of 30-year poles was 6.7 meters, and canopy closure was essentially complete. The 80-year type consisted of closely spaced (161 per hectare) trees of small (less than 70 centermeters) diameter at breast height (DBH). The dense canopy of this type permitted only limited development of understory vegetation. Old-growth stands contained larger DBH trees spaced at 114 per hectare. The relatively open canopy permitted extensive development of understory vegetation.

Twenty-one bird species were represented in the bird data. The winter wren, orange-crowned warbler, dark-eyed junco, chestnut-backed chickadee, golden-crowned kinglet, and fox sparrow collectively made up over 75 percent of total observations. Species oriented to shrub substrates for reproduction and nesting exhibited maximum Population Index (PI) values in early successional vegetation. These species were the winter wren, orange-crowned warbler, dark-eyed junco, fox sparrow, hermit thrush, song sparrow, robin, and Swainson's thrush. Species oriented to trees were more abundant in mid to late successional stages and old-growth stands. These species were the chestnutbacked chickadee, Townsend's warbler, golden-crowned kinglet, ruby-crowned kinglet, western flycatcher, Stellar's jay, and varied thrush. Results for the tree swallow, Wilson's warbler, common raven, sharp-shinned hawk, hairy woodpecker, and yellowbellied sapsucker were inconclusive because of the low number of observations. Total PI values were highest in sapling/shrub and pole stands, intermediate in old-growth stands and shrub/sapling stands, and lowest in recent clearcuts and young sawtimber stands.

Bird species diversity and equitability measures were lowest on recent clearcuts. The apparent pattern of bird species diversity response to post-logging succession was an increase over time to some point between the pole and young sawtimber stages. Diversity was depressed in the young sawtimber stage. This effect was attributed to the simple vegetation structure (absence of understory development) characterizing this successional stage. Diversity and equitability measures rose to second peak in old-growth timber where well-developed tree and shrub layers provide structural complexity and suitable feeding and nesting substrates for a variety of species.

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